Name:_____

Person Number:_____

Department of Mechanical and Aerospace Engineering

MAE334 - Introduction to Instrumentation and Computers

Midterm Examination

October 23, 2002

Closed Book and Notes

For each question, choose **ALL THE CORRECT ANSWERS** and mark the corresponding answer or answers on the machine scoring form.

Be sure you put your name and 8-digit person number on both the questionnaire and the scoring sheet.

Failure to turn in this questionnaire with your name and student number on it along with the answer sheet will result in a grade of ZERO.

0. Fill in circle 1 under GRADE OR EDUCATION on side two of your answer sheet (this is your test number!)

1. Waveforms can be broadly classified as:
    a. deterministic
    b. nondeterministic
    c. static
    d. **dynamic**

2. The static sensitivity of a non-linear instrument is:
    a. The slope of the static calibration curve
    b. Constant over the range of the instrument
    c. Variable over the range of the instrument
    d. Proportional to the time constant of the instrument

3. Repeated measurements of the same known static input can be used to quantify the:
    a. precision error
    b. instrument accuracy
    c. static sensitivity
    d. bias error

4. The lowest resolvable frequency in a discrete Fourier transform of a periodic signal is:
    a. the (data sampling frequency)/2
    b. the (data record length)$^{-1}$
    c. the (number of data points)$^{-1}$
    d. the Nyquist frequency

5. The highest resolvable frequency in a discrete Fourier transform of a periodic signal is:
    a. the (data sampling frequency)/2
    b. the (data record length)$^{-1}$
    c. the (number of data points)$^{-1}$
    d. the Nyquist frequency

6. The Fourier transform is:
    a. a reversible transform
    b. can be approximated in a discrete form by a sum of sine and cosine functions
    c. is not appropriate for use with periodic wave forms
    d. is a complex valued function

7. An 8 bit ADC with a 2 volt input signal range has a finer resolution than a 10 bit ADC with a 10 volt input signal range.
    a. True
    b. False

8. The temperature resolution of a 10 bit digital thermometer with a 102.4 degree range is:
   a. 0.1 degrees.
   b. $102.4/2^{10}$ degrees.
   c. 1 degree
   d. 10 degrees

9. The Nyquist frequency is:
   a. twice the highest frequency in the signal
   b. half the highest frequency in the signal
   c. half the sampling frequency of the signal
   d. twice the sampling frequency of the signal

10. Assigning a finite precision number to an infinite precision value is called
   a. Truncation
   b. Quantization
   c. Aliasing
   d. Resolution

11. The slowest sampling frequency given that would avoid aliasing the waveform $y(t) = 5\sin(2\pi t) + 8\cos(4t)$ is (Either a or c will be accepted)
   a. 2π samples/sec.
   b. 4π samples/sec.
   c. 2 samples/sec.
   d. 4 samples/sec.
   e. 8 samples/sec.

12. If t is in seconds, the frequency in Hertz of $y(t) = 12\sin(42\pi t)$ is:
   a. 12
   b. 42
   c. 42π
   d. 21
   e. none of the above.

13. The binary representation of 6 is:
   a. 0101
   b. 1010
   c. 0110
   d. 1100

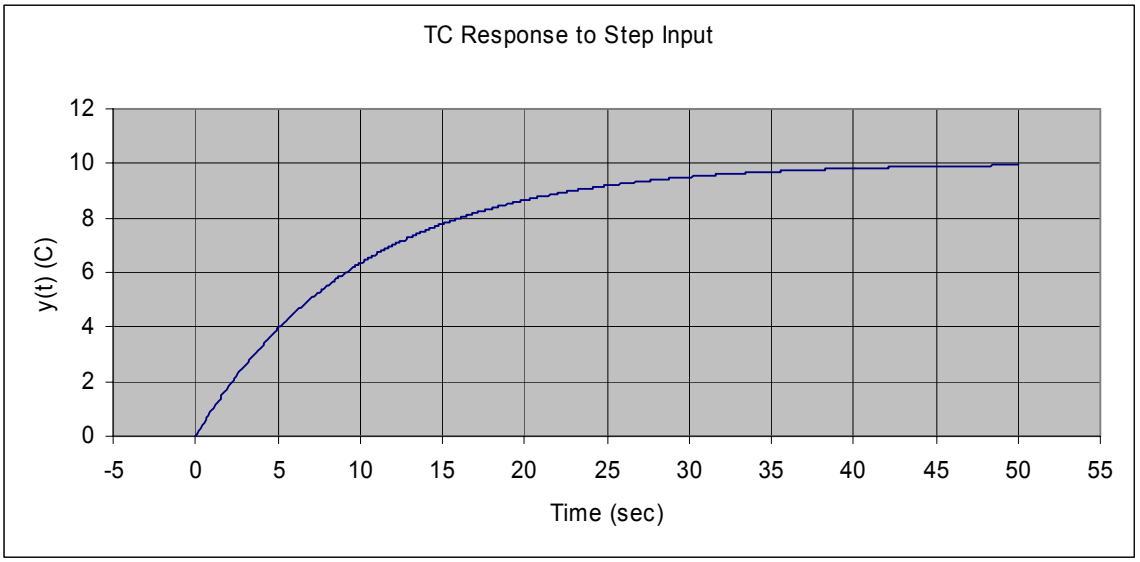
14. The 4 bit 2's complement representation of -1 is:
   a. 1000
   b. 0001
   c. 1111
   d. 1110

15. The second moment is also known as
    - **a. The variance**
    - b. The standard deviation
    - c. The mean
    - d. The time constant

16. The variance is the square root of the standard deviation of a data set?
    - a. True
    - **b. False**

17. Using the nomenclature from the text book and class, S_x refers to the
    - **a. Sample standard deviation**
    - b. Standard deviation
    - c. Variance
    - d. Standard error of the fit
    - e. Correlation coefficient

18. For a normally distributed data set, as S_x increases
    - a. The 95% confidence interval of the estimation of the true mean gets smaller.
    - **b. The 99% confidence interval of the estimation of the true mean gets larger.**
    - **c. The signal variance gets larger.**
    - **d. The probability density function becomes wider.**



19. The time constant, τ, of the thermocouple response plotted above:
    - **a. is independent of the input signal waveform.**
    - **b. is approximately 10 seconds**
    - c. is approximately 25 seconds
    - d. is approximately 50 seconds
    - **e. is proportional to the slope of ln((*y*(*t*)-10)/-10) vs. *t***

20. The output signal of the thermocouple with the step input response plotted above to a sinusoidal temperature fluctuation of y(t)=10sin(2πt) would:
    - **a. Be severely attenuated**
    - b. Be slightly attenuated
    - **c. lag behind the input signal.**
    - d. be linear.

21. A linear regression analysis yields the following result for a calibration data set with 20 points (Use the student's t-distribution table on the last page):

$$y = 1.45\,x + 0.05 \pm 0.1 t_{\nu,95\%} \quad (95\%)$$

    For a value at x=1, 95% of the points are expected to lie in the range:
    - **a. 1.45+0.05-0.1*2.101 < y < 1.45+0.05+0.1*2.101**
    - b. 1.45+0.05-0.1*2.093 < y < 1.45+0.05+0.1*2.093
    - c. 1.45+0.05-0.1*2.086 < y < 1.45+0.05+0.1*2.086
    - d. none of the above

22. To decrease the confidence interval size, CI, in which the predicted dependent variable value should lie we could:
    - **a. increase the number of calibration points.**
    - b. increase the CI percentage from 95% to 99%.
    - c. decrease the number of calibration points.
    - **d. decrease the CI percentage from 95% to 90%.**

23. A second order system is said to be underdamped when the damping ratio is
    - a. greater than 1
    - b. equal to 1
    - **c. less than 1**
    - d. equal to 1.707

24. The rise time of a second order system subjected to a step input is
    - a. the time required for the signal to reach approximately 2/3 of the distance to the steady state response to the step input.
    - b. the time required for the signal to settle to within 10% of its steady state response to the step input.
    - **c. the time required for the signal to reach approximately 90% of its steady state response to the step input.**
    - **d. equal to the settling time if the system is overdamped.**

25. The plot of the histogram of a finite data set
    - **a. gives an indication of the variance of the data set.**
    - **b. approximates the probability density function if the data set is large.**
    - **c. is shaped like a "bell" curve for a normal, Gaussian, distributed data set.**
    - **d. is flat if the input signal is a triangle wave.**
    - e. is flat if the input signal is a sine wave.

26. The time constant (τ) of a thermocouple (like the one tested in Lab 2) can be effected by the following factor(s)?
    a. size of the temperature step.
    b. the direction of the temperature change.
    c. the medium around the thermocouple.
    d. the size of the thermocouple.
    e. rapidly stirring the water with the thermocouple.

27. Which of the following is an indication of the linearity of a static calibration?
    a. the correlation coefficient, R
    b. slope of the regression line
    c. the size of the 95% confidence interval
    d. the standard error of the fit, S_{xy}

28. The number of degrees of freedom, ν, of the standard deviation, S_x, of a Gaussian distributed data set with N points is:
    a. N-2
    b. N -1
    c. N
    d. N +1
    e. N +2

29. Given the Gaussian distributed data set, the uncertainty in the mean value could be reduced by:
    a. increasing the sensitivity of the measuring instrument.
    b. decreasing the total number of measurements.
    c. improving the precision of the measuring instrument.
    d. improving the quality of the calibration.

30. Given a calibration data set with 56 data points the number of degrees of freedom, ν, of a third order regression fit would be:
    a. $\nu = 52$
    b. $\nu = 53$
    c. $\nu = 54$
    d. $\nu = 55$
    e. $\nu = 56$

31. A stationary random process
    a. has a mean value that does not vary with time
    b. has a variance that may vary with time
    c. has an autocorrelation that is constant
    d. is also an ergodic process

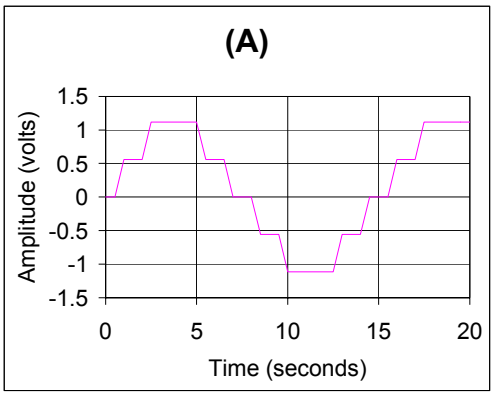


Figure 1. Sampled Sinusoidal Waveform.

32. The waveform sampled in Figure 1
    a. has a mean value approximately 1.
    b. has a period of approximately 15 seconds.
    c. has a frequency of approximately 15 Hertz.
    d. shows signs of quantization error.
    e. has a frequency of approximately $2\pi/15$ radians/second.

33. The discrete Fourier transform of the waveform sampled in Figure 1
    a. would contain 1 Fourier component
    b. would exhibit a phenomena known as leakage
    c. would improve in quality with a much longer sampling period
    d. could contain frequencies as low as 1/20 of a Hertz

Table 1. Student's t-distribution table.

	Student-t Distribution			
ν	**50%**	**90%**	**95%**	**99%**
1	1.000	6.314	12.706	63.656
2	0.816	2.920	4.303	9.925
4	0.741	2.132	2.776	4.604
5	0.727	2.015	2.571	4.032
6	0.718	1.943	2.447	3.707
7	0.711	1.895	2.365	3.499
8	0.706	1.860	2.306	3.355
9	0.703	1.833	2.262	3.250
10	0.700	1.812	2.228	3.169
11	0.697	1.796	2.201	3.106
12	0.695	1.782	2.179	3.055
13	0.694	1.771	2.160	3.012
14	0.692	1.761	2.145	2.977
15	0.691	1.753	2.131	2.947
16	0.690	1.746	2.120	2.921
17	0.689	1.740	2.110	2.898
18	0.688	1.734	2.101	2.878
19	0.688	1.729	2.093	2.861
20	0.687	1.725	2.086	2.845